

ENVIRONMENTAL REPORT
Operation, Maintenance and Management
of
EDWARD MACDOWELL LAKE
Dublin, Harrisville, Hancock and Peterborough
New Hampshire

~~Prepared for:~~

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I. PROJECT DESCRIPTION

A. INTRODUCTION

1. Location and Authorization

The Edward MacDowell Dam and project area are located in the towns of Dublin, Harrisville, Hancock and Peterborough, New Hampshire. The dam was built across the Nubanusit Brook in Peterborough, a tributary of and close to the headwaters of the Contoocook River. The dam is one-half mile upstream from the village of West Peterborough and 14 miles east of Keene.

Authorization for the Edward MacDowell Dam was contained in the 1936 Flood Control Act (Public Law 761) and modified by the 1938 Flood Control Act.

Edward MacDowell Dam and Reservoir were constructed at a total cost of \$2,034,300 and the project became operational in March of 1950.

2. Purpose

The project is one of three Corps projects, the others being Hopkinton-Everett Lakes and Blackwater Dam, built in the Contoocook River basin. It provides substantial flood protection for Peterborough and other communities in the upper Contoocook River basin and, integrated with other Merrimack River basin projects, it also provides a measure of protection to potential damage centers further downstream on the Contoocook and along the Merrimack River. The MacDowell Dam controls about one-third, or 44 square miles, of the Contoocook drainage basin above Peterborough; the rest of the upstream waters of the Contoocook are uncontrolled until they flow into the impoundment area behind Hopkinton Dam, 35 miles downstream on the Contoocook, near the town of Hopkinton.

B. STRUCTURES AND RESERVOIR

1. Dam

Edward MacDowell Dam, built across Nubanusit Brook, is of the rolled-earth type with a dumped rock blanket on the upstream face and a rock toe on the downstream face. It is 1030 feet long with a maximum height of about 63 feet above stream bed. The elevation of the top of the dam is 967 feet above mean sea level (msl) and a roadway extends the length of the dam. Designed surcharge at the dam is 15 feet, to an elevation of 961 feet msl.

2. Spillway

The spillway is located 3.2 miles north of the dam, just northeast of Half-moon Pond. Discharge is designed to flow into Ferguson Brook and thence into the Contoocook River downstream from Peterborough. The chute spillway has an ogee weir, 100 feet long, with a crest elevation of 946 feet msl. In conjunction with the spillway channel, which is cut through bedrock, is a low dike, paralleling the channel on the north side and built to contain the spillway discharge. The spillway channel is about 1700 feet long. Two public roadways, one above and the other downstream from the weir, cross the spillway channel on bridges. Designed surcharge at the spillway is 12.2 feet, or 958.2 feet msl, reflecting a 2.8-foot loss of hydraulic head which would accumulate over the more than three-mile distance separating the dam from the spillway. Maximum discharge capacity at the spillway is 16,600 cfs.

3. Outlet Works

A seven-foot square conduit, 275 feet in length, passes under dam. Flow through it is controlled, from the intake tower, by three slide gates, each three feet by seven feet. The conduit empties into a 25-foot by 40-foot stilling basin and then into a small pool upstream of the old Verney Mills Dam.

Maximum discharge capacity from the outlet works with flood waters at an ele-

vation of 946 feet msl is 1600 cfs. Downstream safe channel capacity of Nubanusit Brook, however, is about 650 cfs.

4. Reservoir

A small permanent pool or conservation pool is maintained upstream from Edward MacDowell Dam. Its surface elevation varies from about 910 feet msl in the summer to 912 feet msl in the winter. Surface area of this pool is approximately 165 acres. The pool is maintained both in order to protect the outlet gates from freezing during the winter months and to enhance fisheries and wildlife habitat year-round.

Within the rest of the project area there are three other smaller permanent bodies of water: Halfmoon Pond, the surface elevation of which is normally controlled by the spillway weir at the pool's northeast perimeter (with a crest elevation of 946 feet msl), and Dinsmoor and Beaver Ponds, short distances to the west and northwest of Halfmoon Pond. The latter two ponds are somewhat smaller than Halfmoon Pond, and have slightly higher normal surface elevations. Because all three ponds are upstream from the dam by more than three miles, impoundment of flood waters first occurs in the pool just behind the dam and the level of stored water only gradually retreats northward to the area of these natural ponds.

The potential reservoir at spillway-crest elevation 946 feet msl is 840 acres in extent, about five miles long, and would contain 12,650 acre-feet of water above the conservation pool. This volume represents 5.4 inches of runoff from the upstream drainage area of 44 square miles. Were the reservoir to be filled to maximum surcharge level (961 feet msl or 15 feet above spillway crest as measured at the dam) the area flooded would be 1,875 acres, with a volume of 18,800 acre-feet.

Since operations commenced at the dam in 1950, the reservoir pool has been filled to more than 50 percent of capacity only three times. The first was in April 1951 (52 percent or 6,700 acre-feet), the next in January 1956 (58 percent, to 936 feet msl, or 7,400 acre-feet), and the most recent time

was April 1960 (55 percent, or 7050 acre-feet). One inch of rainfall in the drainage area behind the dam is equivalent to about 2350 acre-feet of stored water.

The perimeter of the project, as calculated for an elevation of 949 feet msl, equivalent, approximately, to the boundaries of the land owned in fee by the Corps, is about 12 miles in length.

5. Real Estate

The Corps of Engineers has acquired 1194 acres in fee. This acreage, as noted just above, approximates the area included within the contour line which defines an elevation of 949 feet msl. An exception to this is the land bordering Halfmoon Pond, which is owned by Boston University and on which the University operates its Sargent Camp. There, and also on 156 acres of the low land below the spillway channel bordering Davis and Ferguson Brooks between Middle Hancock Road (sometimes called "Tenney Road") and Route 202, acreage has already been, or soon will be, acquired by the Corps as flowage easement land.

C. OPERATION PROCEDURES

Though a formalized manual for reservoir regulation at Edward MacDowell Dam is not now available in final form it may be presumed that procedures and regulation of the flood control facilities at this project are similar to those at others under the supervision of the New England Division of the Corps.

1. Normal Operations

A permanent conservation pool is maintained behind Edward MacDowell Dam. Elevation of the pool during the winter is from 911 to 912 feet msl during the winter and one or two feet lower during the summer. Winter pool elevation is sufficient to protect the gates from freezing. No other special provisions for altering the elevation of the pool during nonflood periods

have been incorporated in the reservoir regulations.

Until recently the old, privately constructed Verney Mills Dam a few hundred yards downstream from MacDowell Dam on Nubanusit Brook had been responsible for maintaining pool level in the permanent reservoir pool behind MacDowell Dam. This was so because water behind this downstream dam backed up through the outlet works of MacDowell Dam. In recent years, because the older dam posed safety problems, it was acquired by the Corps and its spillway was breached to a depth of about eight feet. This action necessitated the regulation of the permanent pool by manipulating the control gates at MacDowell Dam. Normal gate settings are between 0.5 and 0.7 feet on all three gates.

Downstream from the dam, along Union Street in West Peterborough, beavers have occasionally initiated construction work of their own; it is the responsibility of the project manager to periodically remove these uninvited dam-builders and any obstructions to channel flow.

2. Flood Periods

Regulation of flow from the reservoir is initiated for heavy rainfall occurring over the Nubanusit Brook drainage basin and also for specific river stages as measured at the USGS gage on Nubanusit Brook in West Peterborough and the USGS gage on the Contoocook River at Noone's Mill, just upstream from the confluence of Nubanusit Brook.

Regulation may be considered in three phases during the course of a flood; these are described briefly below.

a. Phase I - Initial Regulation of Discharge

During the initial phase of the reservoir's regulation it is necessary to collect rainfall and discharge data in order to appraise the development and magnitude of any incipient flood developing in the watershed. Depending upon antecedent conditions in the watershed unusual amounts of rainfall will produce a more or less serious rise in river and reservoir stages. In gen-

eral, it is standard operating procedure to report rainfall in excess of one inch during any 24-hour period to the Reservoir Control Center (RCC). If communication with the RCC is not possible all gates are to be closed until communication is re-established.

Safe channel capacity downstream from MacDowell Dam is 650 cfs, and less than that if there is ice in the channel. Coordination between the storage and release of flood waters at MacDowell Dam and operations at Hopkinton-Everett Lakes 35 miles downstream is the responsibility of the RCC.

b. Phase II - Continuation of Regulation

An important regulation activity during the second phase of regulation is the collection and relaying to RCC of hydrologic data, such as: (1) precipitation amounts throughout the upper Contoocook River watershed and nearby areas; (2) snow cover and its water content, in the case of spring floods; (3) stage and discharge values at downstream control points; and (4) any other pertinent data which would assist in flood regulation. During this phase, as earlier implied, reservoir discharge is regulated to reduce downstream flooding in Nubanusit Brook, in the Contoocook River below Peterborough and also in the Merrimack River.

A critical downstream locality where flood stages are carefully monitored during this phase in addition to the two USGS gages, is the site of a now-vacant motel on Route 202, just north of Peterborough where that road intersects Sand Hill Road.

c. Phase III - Emptying the Reservoir

Following a flood the reservoir is emptied as rapidly as possible. Stored floodwaters will be released in accordance with instruction issued by the RCC. In general, releases will be based on conditions in the Nubanusit Brook, and in both the Contoocook and the Merrimack Rivers. Specific rates of draw-down are formalized in a reservoir regulation manual presently being prepared for the project. Evacuation discharges from the reservoir will not, however,

exceed safe channel capacities downstream.

It is significant that MacDowell Dam controls only about one-fourth of the runoff from the headwaters of the entire Contoocook watershed above Peterborough. Consideration of the uncontrolled runoff from the rest of the Contoocook headwaters must therefore be a part of any decision to release those floodwaters from the Nubanusit basin which are stored at MacDowell Reservoir.

3. Cooperation with Downstream Water Users

It is the policy of the Corps of Engineers to cooperate whenever possible with downstream users and other interested parties or agencies. The project manager may be requested by downstream users to deviate from normal regulations for short periods of time. Whenever such a request is received the manager shall ascertain the validity of the request, obtain assurance from other downstream water users that they are agreeable to the proposed operation, and request instructions from RCC.

D. MANAGEMENT PROGRAMS

The Reservoir area is being managed, under license, by the New Hampshire Fish and Game Department as a habitat for waterfowl, as well as for other wildlife and fish.

Public recreation facilities are the responsibility of the Corps and the project's one recreation site, principally for picnickers, is located at the west end of the dam structure. Public swimming, except at the privately owned Sargent Camp on Halfmoon Pond, is not encouraged. Snowmobiles are allowed on the service roads of the project, but no formal trail designation program will be initiated by the Corps, at least in the near future. No specified forestry management practices, except for routine maintenance, are undertaken at the project.

II. ENVIRONMENTAL SETTING

A. DESCRIPTION OF GENERAL AREA

1. Climate and Precipitation

The climate of the Nubanusit Brook basin is seasonally variable with a mean annual temperature of 45°F. Average monthly temperatures range from about 69°F in July to approximately 20°F in January.

The area lies in the path of prevailing westerlies but it is also exposed to Atlantic coastal storms, locally known as "nor'easters." Storms of tropical origin, sometimes of hurricane intensity and associated with extremely heavy rainfall, have infrequently occurred in the region during the late summer and early autumn.

The mean annual precipitation in the region is approximately 40 inches and slightly more at higher elevations. Average annual snowfall is about 68 inches.

2. Topography

The Nubanusit Brook basin drains southeastward from its headwaters at Nubanusit Lake 7 miles northwest of MacDowell Dam into the Contoocook River at Peterborough. The drainage divide, straddled by Mount Monadnock about 7 miles southwest of the dam and at an elevation of 3965 feet msl, forms the eastern perimeter of the Contoocook River basin. At the other extreme of elevation, the confluence of Nubanusit Brook with the Contoocook River, the drainage basin has an elevation of approximately 740 feet msl. The region between these extremes of elevation is characterized by rather broad, often marsh-covered, upland valleys bounded by hills and ridges with moderately steep slopes.

3. Vegetative Cover Types

The Nubanusit Brook basin is mostly wooded. An absence of trees is notable only around areas of open water and marsh. The forest cover is dominated by northern hardwoods such as oak, maple, beech, poplar, birch and other species, interspersed with stands of white pine and hemlock. Marsh areas support various associations of grasses, ferns and shrubs.

A minor amount of vegetation, especially autumn olive, has been planted in a few places within the project area.

Small farmsteads dot the area but, in aggregate, the cultivated acreage is a very small percentage of the drainage area.

4. Fish and Wildlife Species Present

Beaver colonies are scattered throughout the Nubanusit Brook drainage area. Deer abound in the area also. It is reported that foxes, porcupines, skunks, snowshoe hares, fishers and river otters also populate the area. Pheasants have been stocked in the area in past years by the New Hampshire Fish and Game Department and ruffed grouse are indigenous. Migrating waterfowl visit the area seasonally and are being encouraged by current wildlife management programs. Until recently the area was managed as a waterfowl refuge; recently, however, designation of the area was changed to simply that of a waterfowl management area.

The shallow permanent ponds and pools provide good fisheries for horned pout, pickerel, perch and bass. The Fish and Game Department annually stocks trout at various points in the basin, especially in the brook below MacDowell Dam. Ice fishing on the ponds is popular in the winter, as is angling for both warm and cold water species at other times of the year.

5. Geologic Features

The area is adjacent to a classical, well studied geomorphological feature,

Mount Monadnock, which has lent its name to other glacially eroded features of the same type elsewhere in the world. It can be inferred from the proximity of the Nubanusit Basin to the Mount Monadnock region, that both had nearly the same geologic history. The area is underlain by a complex of igneous and metamorphic rocks. Long after the bedrock was formed the region was uplifted and then eroded to a nearly featureless surface, from which Mount Monadnock protruded slightly as an anomalous and relatively uneroded prominence. In more recent times, during the Ice Ages and afterwards, further erosional action emphasized the anomaly and has been responsible for sculpturing both the slopes and summit of Mount Monadnock, as well as adjacent areas, and allowing the region's network of rivers and streams to entrench themselves in rather well-defined valleys.

6. Historic and Archeological Features

No historic and archeological features are known to exist within that area which might be flooded by the waters impounded by MacDowell Dam.

7. Socioeconomic Conditions

The waters of the Nubanusit Brook drainage basin rise in eastern Cheshire County in the rural towns of Nelson, Harrisville, Dublin and Jaffrey, and flow in a southwesterly direction into Hillsborough County to Peterborough.

Populations of the four towns in Cheshire County increased from 4519 persons in 1960 to 5078 persons in 1970, an increase of about 12 percent. In that part of the Nubanusit drainage which is within Hillsborough County, that is, the towns of Hancock and Peterborough, the census showed a 28 percent increase from 3685 persons to 4716 persons during the same period.

Peterborough and Jaffrey, each with a population of between 3000 and 4000, are the two largest towns in the immediate area, jointly comprising close to 75 percent of the region's population. Paper mills, printing plants and other industrial water-users are located along the Contoocook in the vicinity of Peterborough. A ball bearing factory is Peterborough's largest employer.

Outside of the two larger towns' developed areas the region is sparsely populated.

Agriculture is not an important source of income in the region. Those farms that exist are family-sized operations and are mostly restricted to dairy operations. Scattered small-scale sawmills and adjunct timber operations are also found in the region.

The transportation network in the area is centered on the two highways which intersect at Peterborough: Route 202, which follows the Contoocook River north and south from the Massachusetts boundary to Hopkinton, and Route 101, which runs east-west from Keene to Nashua. Additional roads serve mostly local traffic.

Recreational use of the area is moderate to heavy, especially in the summer, due mostly to the presence of the many seasonal homes used by vacationers and to the scattered intensive-use recreational facilities (private camps, state parks and ski areas). The region is located midway between two arterial interstate highways which traverse the more densely populated areas of southern New England: Interstate 91 to the west, in the Connecticut River valley, and Interstate 93 to the east, which follows the Merrimack River valley through the cities of Nashua, Manchester and Concord.

B. WATER USES

Within the project area the water resources serve principally to support fisheries and wildlife habitat, and thereby enhance recreational fishing and hunting. However, at Halfmoon Pond and Boston University's Sargent Camp, year-round recreational and educational programs are conducted, some of which utilize that body of water for swimming and other purposes.

C. INTERRELATIONSHIPS WITH OTHER PROJECTS

As earlier mentioned, the Edward MacDowell Dam's flood control operations are integrated with those of Hopkinton-Everett Lakes and Blackwater Dam. All

three projects are managed as part of the larger regional Merrimack River flood control program.

Furthermore, coordination of land and water use within the MacDowell Dam project is arranged through a management agreement between the Corps and the New Hampshire Fish and Game Department. Aside from fishing, hunting and provision for use of the area by snowmobilers and picnickers within specified areas, there is no other organized use of the project lands.

III. ENVIRONMENTAL IMPACT OF THE OPERATION, MAINTENANCE AND MANAGEMENT PROGRAM

A. OPERATION OF PROJECT FOR AUTHORIZED PURPOSES

1. Downstream Effects - Regulation of Flows and Releases

a. Flooding Prevented

The Edward MacDowell Dam is operated in conjunction with Hopkinton-Everett Lakes to control flood stages along the Contoocook River Valley and to desynchronize contributions from that river to the Merrimack River. Also of particular importance is the protection of property in the town of Peterborough, two miles downstream from the dam on the Nubanusit Brook and at the confluence of that brook with the Contoocook River.

Peterborough suffered severely from two floods in the recent past, one in March 1936 and the other in September 1938. Damages during the latter flood were compounded by a simultaneous fire which ravaged much of the central business district. The following of one disaster with another, only two years later, certainly must have done much to convince the residents of Peterborough of the need for the flood protection subsequently provided by MacDowell Dam.

There have been 31 significant storage operations, utilizing more than 13 percent of storage capacity, since the project became operational in 1950. Thirteen of these occurred during the month of April, and an additional 11 operations were during the months of January, February and March. It must be remembered, despite the majority of flood control operations in these four months, that serious floods have occurred, and will continue to occur, in places like the Peterborough region during any month of the year.

The MacDowell Reservoir has reached an elevation of 925 feet msl or more, representing 28 percent or more of the reservoir's capacity, on 12 occasions since it was built in 1950. The broad flood plain of Nubanusit Brook between

West Peterborough and the west edge of Peterborough's central district is vulnerable to very high flood stages, the frequencies of which are now much reduced by the presence of MacDowell Dam. Development of this flood plain area has proceeded with apparent caution, although flood plain zoning ordinances have not yet been enacted by Peterborough.

The narrow gorge through which Nubanusit Brook flows just as it enters the center of Peterborough marks a distinct change in gradient and velocity for the Brook, a fact which had serious consequences in the floods of 1936 and 1938. Upstream at West Peterborough, the village just one-half mile below the dam, some structures have been located within the brook's flood plain. Serious flood damage along the Nubanusit last occurred in 1938. Since the erection of MacDowell Dam, however, only a minimum of flood damage has been reported from the Nubanusit basin, either in West Peterborough or in Peterborough.

Serious flooding within the Contoocook River Valley downstream from Peterborough and along the 35 mile-stretch to Hopkinton Dam was also last recorded in 1938, when damages were quite severe. The towns of Bennington, Antrim, Hillsboro and Henniker are located in this part of the Contoocook Valley. Between these towns the valley's wide flood plains are dotted with occasional hayfields and pastures, but most of the area is woodland or marshland.

b. Fish and Wildlife

The New Hampshire Fish and Game Department normally stocks the Nubanusit below West Peterborough with brown trout. Trout are also stocked downstream in the Contoocook with probably little carry-over in this stretch of river, and so the stocking is considered to be on a "put-and-take" basis.

Significant changes in downstream flow patterns due to operation of Edward MacDowell Dam occur very rarely, in most years perhaps for a few days up to one or two weeks. In many cases regulation may be conducted without restricting reservoir outflows to less than several hundred cfs during the course of a flood. The reduction of peak flows from this fairly small watershed prob-

ably has negligible effect on either the downstream fishery or wildlife inhabiting flood plain areas along the Nubanusit. The necessity of maintaining a clear channel for passage of flood waters affects beaver indirectly, since the animals have to be removed whenever they move into downstream reaches of the brook.

Flows of the Contoocook at Peterborough and further downstream are comprised largely of runoff emanating from tributaries other than the Nubanusit. For this reason the flow regime of the Contoocook is not greatly affected, proportionally, by regulation of flow from MacDowell Dam. The Contoocook supports principally a warm water fishery populated by smallmouth and largemouth bass, pickerel, perch, pumpkinseeds, bullheads and several rough and forage species. Because of the Contoocook's relatively wide valley, including the flood plains, those normal seasonal and otherwise changing volumes of water are accommodated without great rises in water levels. Thus deer yards and other terrestrial habits are not seriously impaired by whatever changes in flow regime produced by regulation of flows at MacDowell Dam.

c. Vegetative Cover and Timber

Beyond the central precincts of Peterborough the Contoocook is alternately a meandering river flowing through wide flood plains and a swift-flowing stream in short reaches of constricted valley. There is considerable natural flood storage provided by the wide marshy flood plains at many spots.

The wide flood plain stretches of the river generally are covered with vegetative types long since adapted to seasonal and periodic floods. Timber stands of commercial and aesthetic value are found at elevations considerably above the flood stages which have been historically recorded along this valley.

Flow regulation in the Nubanusit watershed has relatively minor influence on Contoocook River stages during a flood, and no vegetative changes attributable to this regulation are evident.

d. Water Quality

The Nubanusit and Contoocook waters below MacDowell Dam normally receive some discharges of both treated and untreated wastewater emanating from industrial, commercial, municipal and domestic sources along their courses. However, the impoundment and controlled releases of water by Edward MacDowell Dam take place only during times of high flow, when runoff from uncontrolled drainage areas insures adequate flow for waste assimilation purposes.

e. Recreational Use

The Nubanusit Brook flood plain is the site of Teixeira Park in West Peterborough and the Adams Playground and swimming pool just west of the central business district of Peterborough. Other recreational use of that stream's flood plains is nonspecific. There are no reported instances of releases from Edward MacDowell Dam having caused damage or other problems at the recreational facilities in this region.

One or more instances of hazard, however, have been reported in West Peterborough when children playing, or fishing, close to Nubanusit Brook were surprised and frightened by the sudden and unaccounted rise in water levels in the brook. It is conceivable that serious injury, or worse, might occur in the future if steps are not taken to warn the downstream community of sudden flow releases from the dam, especially in those areas near the village where the stream's channel is narrow and restricted.

There are no reported similar instances of either hazard or loss farther downstream along the Contoocook River which might have been occasioned by flow releases or flow regulation at MacDowell Dam.

f. Aesthetics

Vegetative cover along the Nubanusit's banks has adjusted in the more-than-20-year period to the flow regime imposed by the upstream dam. Consequently tree kills and other degradation that might be expected to have an aesthetic

impact is less now than it must have been when flood waters were uncontrolled. Because of the dam's amelioration of those effects traceable to periods of high water, it is probable that vegetation on the downstream flood plains of both the Nubanusit and Contoocook is more stable now than prior to construction of MacDowell Dam.

2. Upstream Effects in Reservoir

a. Fish and Wildlife

The periodic inundation of the MacDowell Reservoir for periods of 10 days or less has had no appreciable effect upon the fisheries in the project area. Some dispersal of the populations from one pond to another has probably occurred during these periods, but the water bodies are interconnected anyway by Nubanusit Brook and tributaries and contain the same species.

The New Hampshire Fish and Game Department has proposed the installation of a low weir across Nubanusit Brook just north of the Spring Road bridge at the site of old Swett's Dam. The proposed weir would be used to stabilize water levels so as to provide improved and expanded waterfowl habitat. Some years ago this same marshland between Halfmoon Pond and the conservation pool was dredged in a pattern of trench-like furrows in an unsuccessful attempt to expand and improve this potentially valuable site for waterfowl nesting and feeding. A 126-acre marsh would be created by the weir if, as the Fish and Game Department hopes and recommends, its spillway elevation is built at about 912.5 feet msl. The decision on when to build the weir is dependent upon state budgetary appropriations and possible federal/state cost-sharing arrangements. The creation of the marsh behind the weir would be an explicit trade of a marginal terrestrial habitat for a decidedly beneficial aquatic habitat. Inundation of the area in the early spring as a result of flood control operations would not have much of an impact on the waterfowl habitat. Later in the season, however, flood storage could damage or destroy those aquatic plants on which waterfowl depend for food.

Wildlife in portions of the reservoir that are periodically inundated may be

affected both by direct losses due to drowning and through alteration of vegetative cover and habitat. Since much of the regularly flooded land is marsh and swamp, aquatic mammals such as beaver, mink, muskrat, otter and others that inhabit the low-lying area are well adapted to and can readily survive changing water levels. The beneficial and detrimental impacts on wildlife of such flooding are not always evident. Winter floods, for example, may result in substantial damage to shrubby vegetation from ice movements. Although the destruction of these plants may reduce the available food supply for browsing species, the Fish and Game Department has pointed out that such ice damage and flooding at any time of year serve a useful management function in retarding succession on open field areas. Interspersion of open and wooded areas is particularly important for enhancing grouse, pheasant and other upland bird habitat. Spring floods and reservoir inundations, while usually having less effect on vegetation than summer or winter floods, may cause losses of waterfowl broods and the young of other species if they occur during the nesting season.

Trappers have taken as many as 16 beaver in one season (1973-74) from the project area. Muskrats, mink and raccoons have also been successfully trapped in the reservoir. Rather precise monitoring of these game harvests is made possible by the fact that the "landowner" permits required of trappers are, in the case of this area, issued by the New Hampshire Fish and Game Department, the primary lessee of the project lands. Furbearers are not generally harmed by, and may even benefit from, reservoir operations and periodic flooding.

b. Vegetative Cover

Much of the regularly flooded area of the reservoir is characterized by swamp and marshland vegetation that is not seriously affected by short periods of inundation. Fluctuating water levels over the past 24 years have had progressively less evident impacts on plant life at higher pool stages and the divisions between open water, marsh, shrub swamp and forest cover reflect to some extent the frequency of flooding at different reservoir elevations.

c. Recreational Use

Public recreational use of the project lands is that which principally involves the activities of fishermen and hunters. Fishermen mostly seek the warm water species of fish to be found in the four permanent ponds within the project's boundaries. An informal boat launch for rowboats and other craft without motors has been established by the public on the east side of the conservation pool; other make-shift launch sites also exist. Waterfowl hunters also frequent the area during the migratory bird season. Periodic storage operations at the dam have temporarily impeded access for fishermen, hunters and trappers but the inconvenience to users is not serious. Impact of such inundation upon the fisheries and waterfowl has not seriously impaired the value of these resources. Winter sports such as snowmobiling, snowshoeing and cross-country skiing are rarely affected by project operations.

Picnicking facilities are provided by the Corps at two sites, one just north of the dam on the west side of the permanent pool (11 tables and eight fireplaces) and another downstream from the dam (five tables and two fireplaces). Neither site is within the flood pool area; therefore, changes in water level have no impact upon the public's use of these facilities.

Alternative and more extensive public recreational facilities for persons visiting the region are to be found at Greenfield State Park, located 10 miles to the north of MacDowell Dam.

Visitors to Boston University's Sargent Camp use Halfmoon Pond and the surrounding land for various recreational activities. The Corps has a flowage easement on this land. The permanent water level at the pond is about one foot below the crest elevation of the spillway, located at the northeast edge of the pond, and flood waters have not yet been backed up into the area. Only when surcharge storage occurs might there be appreciable restriction on use of the camp's land.

d. Beneficial Use of Water

The spillway of the old Verney Mills Dam, just a short distance downstream on Nubanusit Brook from MacDowell Dam, has recently been partially breached so that the level of the conservation pool is now maintained by adjustment of gate settings at MacDowell Dam. The latter dam, until recently privately owned, once provided the source of water-generated power for one or more mills downstream. But at the present time no beneficial use is made by industries or utilities of the waters of Nubanusit Brook within the reservoir area or downstream from it.

e. Aesthetics

A small amount of clearing of land on the margins of the conservation pool was done years ago, but vegetation in most of the reservoir area was left undisturbed. The occasional storage operations in recent years have had no serious or adverse aesthetic effect within the reservoir area; neither have any other accommodations to the project's uses. A borrow pit for sand and gravel used in the construction of the project, just to the east of the permanent conservation pool, has been replanted with pine and autumn olive to cover this landscape scar and improve wildlife habitat. The intrusion of motorbikes into this area is being discouraged by project staff.

B. CONSTRUCTION AND MAINTENANCE OF PROJECT FACILITIES

The picnic facilities close to the dam are conveniently located to attract and serve casual visitors to the project. Because of the extensive wetlands that cover a large part of the reservoir, there are few other sites favorable for development of additional day-use facilities. Because some fishermen prefer to use canoes and rowboats, an improved access point for unloading such craft from cars and trailers would be desirable. Such an access point is already informally established off the reservoir road on the east side of the pool, but it was observed to be somewhat rutted and hazardous for vehicular traffic after a rain. Addition of gravel to this short access spur would improve its attractiveness and convenience.

Bridge improvements on the east-west road crossing Swett's Dam and connecting Miller Row Road to the east of the project have been undertaken in a satisfactory manner.

A proposal to raise the level of the permanent pool has been advanced by the Fish and Game Department so as to permanently flood and improve the potentially valuable waterfowl habitat at the north edge of this pool. This proposal is in addition to that recommending installation of a weir just north of the small bridge at Swett's Dam, which presumably has higher priority. Because the stability of pool level is especially critical for waterfowl during nesting season (April-June) this proposal could best be implemented by the installation of a weir just in front of the control gates to better insure water-level stability than is now possible with manipulation of gate settings. The expense and need for the implementation of this proposal can conveniently and should be deferred pending action on the other proposed project to improve waterfowl habitat just to the north of Swett's Dam.

C. MANAGEMENT OF PROJECT LANDS

1. Rules and Regulations

The main objective of rules and regulations at reservoir lands and waters managed by the Corps is to insure the health and safety of the visiting public. Negative signs and warnings have been held to a minimum so that the public may enjoy the greatest freedom without unnecessary restraint.

Incursion of trail bikes into areas not intended for vehicular use is always a problem, inasmuch as it degrades environmental values and adversely affects the enjoyment of the project area by those travelling on foot. Restrictions on motorbike use might well be included in the signs normally posted at project boundaries and access points. Although use of the project area by snowmobiles is tolerated, their travel in areas other than along old roads and specific trails should be discouraged. Special care should also be taken to warn snowmobilers if ice conditions are unsafe.

2. Wildlife Management

The principal focus of wildlife management programs at MacDowell Reservoir is on aquatic ecosystems. The New Hampshire Fish and Game Department has judged that terrestrial systems are marginal at best and that upgrading of the habitat for waterfowl and other beneficiaries of a managed aquatic environment is justified. Proposals to improve and expand the waterfowl habitat, as earlier mentioned, are consistent with this evaluation. The decision to abandon the area as a waterfowl refuge and to adopt instead the principles of general waterfowl management was recently made after discovering that visiting numbers of waterfowl were no greater during the hunting season than before it opened. The Department is similarly abandoning 10 or 12 other waterfowl refuges throughout the state since they are not serving the purpose for which they were intended.

Though there has, in the past, been stocking of pheasant on project lands there has not been any stocking recently. There is, moreover, little good pheasant habitat within the boundaries of the project and so this decision appears to be a rational one. The same can be said about the absence of any effort to stock the area with snowshoe hare.

Beaver and other fur-bearing species move into the area from time to time and are harvested by trappers. No specific management program to improve or control populations of these species is presently undertaken, and none seems necessary at this time.

The existing and proposed wildlife management programs appear to be compatible with other uses of the area. Though the proposed construction of two weirs, one above Swett's Dam and the other in front of the outlet gates, is intended to improve waterfowl habitat, both of these efforts would have an additional and beneficial effect on warm water fisheries. In addition to the enlargement of warm water fish habitat, water levels in the impoundments would generally fluctuate less and fish spawning and feeding areas would thus be more stable. Use of the area by recreationists other than fishermen and hunters would be little, if any, impaired by the implementation of these

proposals.

3. Recreational Use and Management

Much of the recreational use of the MacDowell Reservoir area is adjunct to the utilization of the area's fish and wildlife resources. Greater emphasis on day-use by picnickers, for example, is not justified because of the lack of environmental diversity and the paucity of good sites. Neither does there appear to be any justification for the establishment of camping facilities at the project.

4. Forestry Management

The absence of good timber-growing sites, except in small areas, requires little more in the way of forestry management than the occasional removal of snags in waterways and at other places where vegetation interferes with the utility of the project lands.

Periodic inundation here seems to have had the incidental and from one point of view, at least, the beneficial effect of setting back natural vegetational succession so as to maintain good waterfowl habitat.

The New Hampshire Department of Forestry has concluded that the benefits from a specified and routine forestry management program at MacDowell Reservoir, similar to those undertaken at the Blackwater and Franklin Falls projects are not justified by the costs of implementation.

IV. ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED AS A RESULT OF THE OPERATION AND MAINTENANCE PROGRAM

A. FISH AND WILDLIFE

Periodic filling of the reservoir, as at other flood control projects, has had some adverse environmental effects. In the case of MacDowell Reservoir where much of the project land is marsh to begin with, impacts are mostly restricted to the terrestrial ecosystems. The populations of burrowing wildlife, including insects, rodents and other small animals, are vulnerable to inundations; the severity of impact is mostly dependent upon the season when inundation occurs. Nesting waterfowl may, at times, suffer losses of broods and food supply, depending on the season of flooding and the duration of high water levels.

Reservoir fluctuations unavoidably disrupt warm water fish habitat and may adversely affect spawning success, although no actual observations or field data have been collected to estimate the magnitude or importance of such changes. No downstream effects of flow regulation on fish and wildlife in the Nubanusit have been reported. The reduction of spring freshet flows may curtail flooding of undeveloped riverine wetlands, but this effect is unavoidable because of the need to protect structures located in other flood plain areas.

B. WATER QUALITY

The release of flood waters sometimes results in temporary increases in downstream turbidity. Although unavoidable, it is doubtful that such short-term changes have any measurable adverse effect on water and stream uses below the dam. No other parameters of water quality appear to be detrimentally affected by the authorized operations at MacDowell Dam.

C. VEGETATIVE COVER AND TIMBER

Inundation of the reservoir area, and of the plants and trees growing thereon,

may occur at any time of the year, though flooding is most liable to occur in the springtime. If, however, flooding of the reservoir occurs during the height of the growing season and lasts for more than a few days serious damage or loss of most of the vegetation which is overtopped by the floodwaters may occur.

Periodic inundation has the effect of setting back, or delaying, successional stages of vegetative growth. As earlier explained this may be considered an adverse effect by those valuing natural environments but, in the case of a managed waterfowl habitat, there are compensating beneficial effects.

D. BANK EROSION

Some bank erosion has occurred on the west side of the permanent pool as a result of high stands of impounded water. This section of the reservoir's perimeter, generally well forested, is the only upstream area susceptible to bank erosion, the rest of the area being fairly flat and gradually transitional between open water and low-lying marsh. Existing roads and culverts in the reservoir area do require maintenance and some rehabilitation as the result of wash-outs after inundation.

There has not yet been discharge of water through the spillway channel, which is cut mostly through solid rock, but, if and when there is, serious erosional damage will result from the very high flows into the discharge channel leading to Ferguson Brook.

V. ALTERNATIVES TO THE OPERATION, MAINTENANCE AND MANAGEMENT PROGRAM

A. DISCONTINUANCE OF AUTHORIZED FLOOD CONTROL OPERATION

The damage inflicted on Peterborough during the 1936 and 1938 floods is well remembered by many who still reside and work in that town. The rebuilding and expansion of much of the central business district along the banks of the Nubanusit and Contoocook has been undertaken, however, since the Edward MacDowell Dam was built. The increased safety afforded by the dam has certainly been taken into account. Should there cease to be protection from floods which is now provided by MacDowell Dam it is undeniable that property values in an important part of Peterborough would plummet and the threat of a major flood disaster would increase greatly.

Because alternative flood control measures such as flood plain zoning have been slow to be accepted and implemented in the Contoocook Valley, as elsewhere, there has been a gradual encroachment by all sectors of society upon the vulnerable flood plains. A decision made now or in the future to discontinue the protection now afforded by MacDowell Dam should include assessment of the added risk and costs imposed by development and growth taking place in downstream flood-prone areas.

B. LAND MANAGEMENT ALTERNATIVES

1. Discontinuance of Land Management Activities

Land management activities at MacDowell Reservoir, besides those supporting the project's flood control operations, are carried out mainly by the New Hampshire Fish and Game Department to enhance the fisheries and wildlife resources of the area. Without conscious management, particularly of waterfowl habitat, it is likely that the stock of these resources would diminish and their utilization by the public would decline. Increasing pressures on game of all sorts is the result of not only larger numbers of hunters but also the intrusion of man-made developments into wildlife habitats everywhere and

the despoilation of food and other essential resources. The preservation, conservation and enhancement of an environment well suited for species which are under such increasing pressures is the aim of the present management activities.

2. Single Purpose Versus Multiple Use Management

Fisheries and wildlife management, with an emphasis on the improvement of waterfowl habitat, are the only current and specific management practices undertaken on the project, and even these are presently on a maintenance basis until proposals for expanded management can be evaluated and funded.

Project lands are available for nonintensive recreational use by fishermen, hikers, picnickers and snowmobilers at the present time. But there are limitations on these activities due to the area's topography and recurrent flooding. The permanent pool area presents problems for development of a shoreline picnicking and swimming facility because of the pool's shallow depth and regular inundation. Areas further upstream in the reservoir are also not very feasible for intensive day-use recreation because of their natural wet-land character. Therefore, since much of the reservoir is marsh and shallow open water the year around, the greatest potential for expanded recreational use is in those activities which focus on the aquatic resources. Access by fishermen to Beaver and Dinsmoor Ponds, for example, remains a problem. The opening of paths through the clumps of reeds and other vegetation encircling these ponds might invite greater visitation by duck hunters and fishermen with small and light-weight watercraft.

The addition of facilities for a swimming beach is not recommended for the reasons mentioned above and because of site and access limitations for the supporting facilities, at a minimum, a comfort station, change house and parking spaces, that would be needed.

Boston University intends to operate its Sargent Camp facilities on Halfmoon Pond as an environmental education center in 1975 and thereafter. Because these plans will include both university student and public participation in

a variety of programs there is the opportunity and possibility of coordination of land use policies by those landowners, including the Corps, with property in the vicinity of Halfmoon Pond. Public participants attracted to Sargent Camp's programs and displays, for instance, may utilize the resources on Corps-owned land. But, potential conflicts may arise as the result of public hunting and snowmobiling on government property, two activities which are now forbidden on the Sargent Camp premises. Therefore, in anticipation of both the possible advantages and conflicts which may result from the new undertaking at Halfmoon Pond, it is advisable that an understanding be reached among the Corps, the New Hampshire Fish and Game Department and Boston University on multiple-use management and other matters of mutual interest in this area.

C. CONSTRUCTION AND MAINTENANCE ALTERNATIVES

1. Environmental Educational Facilities

As just described an environmental education center soon will exist on land adjacent to the project. It is understood that it will be the policy of this center at Sargent Camp to invite interested persons and public groups to take part in a variety of environmentally oriented programs. The opportunity exists for the Corps, in cooperation with persons from Boston University's Sargent Camp, to lay out trails, observational sites, and other facilities which will expand the educational opportunities for visitors to Sargent Camp. Aquatic biologists, limnologists, botanists and waterfowl specialists are among those who would and could find a variety of sites on the Corps-owned land which might be utilized for teaching and demonstration purposes. Some initiative on the part of the Corps, therefore, to coordinate its management policies with the activities now underway at Sargent Camp may be appropriate.

2. Recreational Facilities

The improvement of boat launching facilities at the east side of the permanent pool and opening of new access to Beaver and Dinsmoor Ponds has been discussed earlier in this report.

3. Safety

Because of the concern expressed by one citizen of West Peterborough for the safety of children of that village who are playing on the banks of Nubanusit Brook when rapid changes in outflow from MacDowell Dam occur, it is important that a local warning system be implemented. Such a warning system might utilize an already installed fire alarm system alert, with a special code indicating that the alert was for floodwaters and not for fire. Or it might involve telephoned warnings to strategically placed homes close to endangered locations along the stream.

VI. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

A. SOCIOECONOMIC EFFECTS

1. Flood Control Benefits

The experience of Peterborough and other communities in the region during the 1936 and 1938 flood disasters did much to support the decision to build an upstream flood control structure. Dams in addition to the MacDowell project have, in the past, been proposed for the upper part of the Contoocook Valley, but none have been built. With the construction of MacDowell Dam much of the town of Peterborough could be rebuilt in the 1950's and 60's within the limits of safety provided by upstream storage. Had the dam not been built much of present-day Peterborough would be under the constant threat of serious flooding. Alternatively, had the decision been made to relocate those businesses and enterprises which had previously been developed in the potential floodway, the town of Peterborough would be quite a different place today.

Choice of options such as that made at Peterborough is most efficiently made at the local level. But at the same time, there is a high degree of regional interest in what at first glance appears to be a matter of local concern. This interest arises from the complex interdependencies which exist: state and federal tax support for flood control measures, a town's provision of regional services, regional economic demands upon industries and other facilities in population centers and other factors. Therefore, the growing concern for the complete array of flood management alternatives will influence future decisions which involve appraising flood risk, land use and the like in the Nubanusit and downstream Contoocook valleys. Policies which balance economic growth in flood-prone areas with the cost of flood protection and also take into consideration environmental and social values, are of considerable import to many groups and agencies today. Although Edward MacDowell Dam provides very real flood control benefits, it is recognized that structures alone cannot solve the flood problem and other strategies are needed in the long run to complement structural flood control programs in the Contoocook basin.

2. Recreational Benefits

There has been minimal commitment of the project's resources to improve recreational uses, and the options for future development of some specific, mostly water-related recreational benefits remain. However, existing uses of the project's land and water resources for hunting, fishing, snowmobiling, boating, hiking and other pursuits are perhaps best served by the absence of developed recreational facilities. Therefore, deferral of a commitment to provide for increased picnicking and other concentrated recreational land uses should continue until periodic reviews justify policy changes which might, in time, support development of facilities for more intensive uses of the project. The avoidance of a course of action leading to high visitation, such as might occur with expanded picnicking areas and provision of swimming facilities, may be the best way to maintain and enhance the long-term productivity and value of the reservoir, simply because relatively natural, unspoiled and undeveloped land is becoming more and more scarce.

The management of fisheries and wildlife resources at MacDowell supports short-term uses of the reservoir by hunters, fishermen and others, but at the same time it is the aim of these management programs to sustain the long-term productivity of the wildlife resources.

3. Biological Communities and Ecosystems

Alteration of flow patterns in the Nubanusit and downstream Contoocook valleys does not appear to have had serious or lasting effects on fish, wildlife, or vegetation in these areas. Furthermore, runoff from uncontrolled drainage areas both upstream and downstream from Nubanusit Brook on the Contoocook River masks whatever flow deficiencies are caused by impounding flood waters at MacDowell Dam. Some short-term benefits are afforded those few persons who grow hay and pasture forage on the Nubanusit flood plains and whose crops are saved from periodic inundation. The same protection, but to a lesser extent, is given to agricultural areas downstream from Peterborough. But, because the replenishment of nutrients provided by floodwaters periodically covering flood plains is denied these same areas, this action may be detri-

mental to the ecology of the flood plains in the long run.

In addition, and often more significantly, the productivity of biological communities is seriously threatened by the encroachment of developments of one sort or another into the flood plain areas than by alteration of a river's flow regime. Structural devices affording some measure of flood protection often encourage this kind of encroachment on natural flood plains. When the conflict or competition between these two incompatible uses of resources of the flood plains is resolved in favor of development, the long-term productivity of natural ecosystems is thereby destroyed.

VII. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF
RESOURCES WHICH ARE INVOLVED IN THE OPERATION AND MAINTENANCE PROGRAM

A. LOSS OF NATURAL RESOURCES DUE TO PERIODIC FLOODING AND CONSTRUCTION

Because much of the area of MacDowell Reservoir was marsh and open water long before the dam was built, the irretrievable commitment of natural resources to the project is less severe than it might otherwise have been. Some areas, however, as for example the east side of the reservoir, were once wooded and have now become brush-covered. Periodic inundation has the effect of preventing vegetational succession, and areas from which forests have been removed or prevented from reestablishing themselves are, and will be, unproductive of timber resources for as long as flood storage operations are continued. In the present regional context, however, this loss is not serious.

The construction and maintenance of the spillway channel where only brush is now allowed to grow is a similar instance of the loss of woodland resources, both plant and animal. In addition to the physical removal of a woodland habitat and replacement by a rock-bottomed, brush-covered, linear zone there has been some local interference with wildlife migration and range patterns imposed by this man-made and fenced zone. Though adjustments have been made by the animals affected, the continued existence of this barrier has the effect of restricting or influencing the ranges, and therefore the numbers, of some species that might be expected to traverse the north-south ridge lying just east of most of the project lands.

Vegetational losses, and also those losses which occur to animal life supported by those resources, are judged to be relatively insignificant throughout the remainder and major part of the project.

VIII. COORDINATION WITH OTHER AGENCIES

Coordination with several federal, state and local interests resulted in valuable input to this assessment. The following is a list of those with whom coordination took place:

Bureau of Sport Fisheries and Wildlife
New Hampshire Fish and Game Department
New Hampshire Division of Parks
New Hampshire Division of Forestry
Monadnock Region Association
Boston University's Sargent Camp